METHOD OF FABRICATING A SOLID-STATE IMAGING DEVICE

CROSS REFERENCES TO RELATED APPLICATIONS

[0001]

The present document is based on Japanese Priority Document JP 2002-255643, filed in the Japanese Patent Office on August 30, 2002, the entire contents of which being incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002]

1. Field of the invention

[0003]

The invention relates to a method for fabricating a solid-state imaging device in which a metallic light shield film is formed to avoid a light coming into an area other than a light receiving sensor.

[0004]

2. Description of Related Art

[0005]

Figs. 4A to 4D show steps of a conventional fabricating process of a solid-state imaging device. Conventionally, a solid-state imaging device is obtained by forming, as shown in Fig. 4A, after forming a light receiving sensor 2 which receives an incoming light and saves it as electric charge and a transfer electrode 7 which transfers the saved electric charge on a surface layer of a wafer 1, a metallic light-shield film 9 on the light receiving sensor 2 and the transfer electrode 7.

[0006]

In addition, as shown in Fig. 4B, an opening is

formed on the light receiving sensor 2 of the metallic light-shield film 9 by etching, and, as shown in Fig. 4C, an interlayer film 13 is formed thereon by a CVD process to embed the light receiving sensor 2 and the transfer electrode 7. Then, the interlayer film 13 is reflowed by heat treatment or the like to have the shape of a lens and a lens material 14 is filled to embed the reflowed interlayer film 13 so as to form an inner-layer lens.

[0007]

Fig. 5 is a cross sectional view of the solid-state imaging device obtained in accordance with the above process. In a conventional solid-state imaging device, a light converged through an interlayer lens is photoelectric converted when it comes in the light receiving sensor 2 from an opening of the metallic light-shield film 9. It is not possible to suppress a component which reflects on the metallic light-shield film 9 and comes into the transfer electrode 7 to result in smear among the incoming light. Such a component will be referred to as "smear component" hereinafter.

[0008]

Conventionally, there is a solid-state imaging device in which an anti-reflection film is formed to prevent the light coming into the imaging device from reflecting on the interlayer film constituting the interlayer lens or the like (see Patent Document 1, for example). This solid-state imaging device is made according to a process further including a step of forming the anti-reflection film on the interlayer film and a step of forming an anti-reflection film on the inner-layer lens in addition to the conventional

fabrication process of a solid-state imaging device.

[0009]

In addition, there is another solid-state imaging device in which reflectivity of a metal light-shield film is lowered by forming the metal light-shield film composed of a refractory metal silicide or the like on an interlayer dielectric, poly-crystallizing the metal light-shield film with a heat treatment on a wafer on which the metal light-shield film is formed at a high temperature of 800°C or higher, and oxidizing a surface of the poly-crystallized metal light-shield film (see Patent Document 2, for example).

[0010]

The patent documents referred herein are as follows:

[Patent document 1]

Japanese Patent Application Publication No. Hei 11-103037

[Patent document 2]

Japanese Patent Application Publication No. Hei 8-78651

[0011]

As disclosed in the Patent Document 1, in order to obtain the solid-state imaging device in which an anti-reflection film is formed on the interlayer film and on the inner-layer lens, it is necessary that the fabrication process further includes a step of newly forming an anti-reflection film in addition to the conventional fabrication process of a solid-state imaging device. The step of forming the anti-reflection film is carried out in an apparatus different from that used for steps before and after thereof. Accordingly, it takes time for conveying the films into and out from each apparatus and time duration until completing the product

fabrication will be long.

[0012]

In addition, the Patent Document 2 discloses that the surface of the metal light-shield film is oxidized at a high temperature of 800°C or higher. Refractory metal silicide is the only refractory metal which can withstand such a high temperature. Since a light-shield film composed of a metal such as tungsten (W) and molybdenum (Mo) is too much oxidized under heat treatment in an oxidizing atmosphere at a temperature of 800°C or higher even though it is a refractory metal, it cannot be used as a light-shield film.

SUMMARY OF THE INVENTION

[0013]

Therefore, in the present invention, a method of fabricating a solid-state imaging device is provided which enables to form an anti-reflection film by oxidizing a surface of a metallic light-shield film without adding a fabrication step even though the metallic light-shield film is composed of not only the refractory metal silicide but also metals including tungsten and molybdenum.

[0014]

The method of fabricating a solid-state imaging device of the present invention is a method comprising the steps of forming a metallic light-shield film on a light receiving sensor and a transfer electrode formed on a surface layer of a wafer, forming an opening on the metallic light-shield film on the light receiving sensor by etching, forming an interlayer film, and shaping the

interlayer film to be a lens shape by heat treatment. In the method, an atmosphere of either one or both of oxygen gas and ozone gas is prepared in a chamber for forming the interlayer film, and a surface of the metallic light-shield film is oxidized before the interlayer film is formed.

[0015]

According to the present fabrication method, in the step of forming the interlayer film in the process of fabricating a solid-state imaging device, an anti-reflection film can be formed by oxidizing the surface of the metallic light-shield film by exposing the surface in the atmosphere of either one or both of the oxygen gas and the ozone gas before the interlayer film is formed in the same chamber as that used for forming the interlayer film.

[0016]

At this time, it is possible to oxidize the surface of the metallic light-shield film even though a temperature in the chamber is 500°C or lower. Therefore, it is possible to form the anti-reflection film by oxidizing the surface of the metallic light-shield film without damaging it even in the case of the metallic light-shield film composed of not only the refractory metal silicide but also metals including tungsten and molybdenum.

[0017]

The present invention may bring the following effects.

[0018]

(1) By making up an atmosphere of any one or both of

oxygen gas and ozone gas in a chamber used for forming an interlayer film and oxidizing a surface of a metallic light-shield film, an anti-reflection film can be formed the oxidation of the surface of the metallic light-shield film with the oxygen gas and the ozone gas in the chamber which is also used for forming the interlayer film. Accordingly, it is not required to add further fabrication steps in which another chamber is used.

[0019]

(2) Since the oxidation is carried out with the oxygen gas and the ozone gas in the chamber which is also used for forming the interlayer film, it is possible to freely control a flow rate of the oxygen gas and the ozone gas and oxidation reaction time so that an anti-reflection film having an optimal thickness can be formed by controlling the oxidation level of the surface of the metallic light-shield film.

[0020]

(3) Since the oxidation is carried out in the chamber setting the temperature to 500°C or lower and using the oxygen gas and the ozone gas, it is possible to form the anti-reflection film by oxidizing the surface of the metallic light-shield film without damaging it even in the case of the metallic light-shield film being composed of not only the refractory silicide such as WSi but also metals including W and Mo.

[0021]

It is a matter of course that effects of the present invention are not limited to those described above. The present invention may possibly result in additional effects derived from the above effects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

The above and other objects, features and advantages of the present invention will become more apparent from the following description of the presently preferred exemplary embodiments of the invention taken in conjunction with the accompanying drawings, in which:

[0023]

Figs. 1A to 1E are cross-sectional views showing steps of a fabrication process of a solid-state imaging device in a first embodiment of the present invention, in which Fig. 1A shows a step of forming a metallic light-shield film, Fig. 1B a step of etching, Fig. 1C a step of oxidation, Fig. 1D a step of forming an interlayer film and Fig. 1E a step of forming a lens.

[0024]

Fig. 2 is a cross sectional view schematically showing a chamber used in the step of forming the interlayer shown in Fig. 1D.

[0025]

Fig. 3 is a cross sectional view of a solid-state imaging device obtained through the fabrication process of the present embodiment.

[0026]

Figs. 4A to 4D are cross sectional views showing steps of a conventional fabrication process of a solid-state imaging device.

[0027]

Fig. 5 is a cross sectional view of the conventionally obtained solid-state imaging device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028]

Figs. 1A to 1E are cross sectional views showing steps of fabricating a solid-state imaging device in an embodiment of the present invention, and Fig. 2 is a cross sectional view schematically showing a chamber used in a step of forming an interlayer film shown in Fig. 1D. With reference to Figs. 1A to 1E, a fabrication process of a solid-state imaging device in the present embodiment will be described.

[0029]

First, as shown in Fig. 1A, a light receiving unit (not shown) performing photoelectric conversion is formed on a surface layer of a wafer 1 and a hole accumulation unit (not shown) is formed further thereon so as to form a light receiving sensor 2 of a HAD (Hole-Accumulation Diode: registered trademark) structure comprising the light receiving unit and the hole accumulation unit.

[0030]

In addition, a charge transfer unit 4 is formed on a side of the light receiving sensor 2 having a charge reader unit 3 disposed therebetween, and a channel stop unit 5 is formed on the other side of the light receiving sensor for blocking charge flowing into the charge transfer unit 4 adjacent thereto. Furthermore, an insulating film 6 composed of SiO_2 or the like formed by a thermal oxidation process or a CVD process on a surface of the wafer 1.

[0031]

A transfer electrode 7 composed of polysilicon or

the like is formed at a position almost right above the charge transfer unit 4 on the insulating film 6. Furthermore, another transfer electrode (not shown) composed of polysilicon or the like is formed to overlap each other at a part thereof with the transfer electrode 7. An interlayer dielectric 8 composed of SiO_2 or the like covering the transfer electrode 7 and further the insulating film 6 on the light receiving sensor 2 positioned between the transfer electrodes 7 and 7 is formed on the surface, that is, on top and side planes of the transfer electrode 7.

[0032]

On the interlayer dielectric 8, a metallic light-shield film 9 is formed to cover the transfer electrode 7. Then, as shown in Fig. 1B, almost all of the part right above the light receiving sensor 2 is etched off to have an opening. Any of metals including W, Mo, Al and the like or WSi being a refractory metal silicide may be used as the metallic light-shield film 9 as far as they can withstand oxidation at a temperature of 500°C or lower.

[0033]

Next, an interlayer film 13 (see Fig. 1D) is formed using a CVD apparatus as shown in Fig. 2. The CVD apparatus shown in Fig. 2 is to uniformly introduce a material gas supplied from a gas line 23 through a shower head 24 in a chamber 22 heated to be a temperature of 500°C or lower, for example, around 380°C -to 400°C by a heater lamp 21 so as to deposit a creative product by reaction of the material gas on the wafer 1 placed on a stage 25 in the chamber 22.

[0034]

In the fabrication process of the present embodiment, oxygen gas 10 and/or ozone gas 11 is introduced to the gas line 23 before the material gas for forming the interlayer film 13, that is, before forming the interlayer film 13 (see Fig. 1C). Accordingly, an atmosphere of the oxygen gas 10 and/or the ozone gas 11 at a temperature of 500°C or lower is filled in the chamber 22 so that the wafer 1 on the stage 25 is exposed in the atmosphere. Therefore, a surface of the metallic light-shield film 9 on the wafer 1 is oxidized so that an anti-reflection film 12 is formed.

[0035]

After the anti-reflection film 12 is formed, the oxygen gas 10 and/or the ozone gas 1 is exhausted from an exhaust pipe 26, and then, a material gas (for example, TEOS (tetraethoxysilane)) for forming the interlayer film 13 is introduced in the chamber 22. Therefore, the interlayer film 13 composed of SiO_2 or the like is formed to cover the anti-reflection film 12 and the interlayer dielectric 8 exposed right above the light receiving sensor 2.

[0036]

Next, the interlayer film 13 is reflowed by heat treatment or the like to have the shape of a lens and a lens material 14 such as SiN is filled to embed the reflowed interlayer film 13. In this way, an inner-layer lens is constituted between the lens material 14 and the interlayer film 13 and a solid-state imaging device is completed.

[0037]

Fig. 3 is a cross sectional view of the solid

imaging device obtained in accordance with the above process. In the solid-state imaging device, a light coming through the inner-layer lens is photoelectric converted in the light receiving sensor 2, and a signal charge obtained by the photoelectrical conversion is read out to the charge transfer unit 4 via the charge reader unit 3 and is further transferred by the transfer electrode 7.

[0038]

Among the light coming through the inner-layer lens, a light reached the transfer electrode 7 reflects on the metallic light-shield film 9. However, in the solid-state imaging device of the present embodiment, since the anti-reflection film 12 is formed by oxidizing the surface of the metallic light-shield film 9, the smear components reflecting on the metallic light-shield film 9 cancel each other due to interference thereof to be reduced. Accordingly, the smear component which conventionally comes into the transfer electrode 7 after reflecting on the metallic light-shield film 9 is reduced to result in improved yield.

[0039]

In addition, in the fabrication process of a solid-state imaging device in the present embodiment, before the interlayer film 13 is formed, the anti-reflection film 12 is formed by oxidizing the surface of the metallic light-shield film 9 using the oxygen gas 10 and/or the ozone gas 11 in the same chamber 22 as that used for forming the interlayer film 13. The interlayer film 13 is formed subsequently, and thus, no additional step using another chamber is required. In other words,

the anti-reflection film 12 can be formed without increasing steps.

[0040]

In addition, since the oxidation is carried out with the oxygen gas 10 and/or the ozone gas 11 in the same chamber 22 as that used for forming the interlayer film 13, it is possible to freely control an oxidation reaction time by adjusting a flow rate of the oxygen gas 10 and the ozone gas 11 from the shower head 24 or time duration until the gases are discharged from the exhaust pipe 26. Therefore, it is possible to form the anti-reflection film 12 having an optimal thickness by controlling an oxidation level of the surface of the metallic light-shield film 9.

[0041]

Furthermore, in the present embodiment, since the oxidation is carried out in the chamber 22 setting the temperature to 500°C or lower and using the oxygen gas 10 and/or the ozone gas 11, it is possible to form the anti-reflection film 12 by oxidizing the surface of the metallic light-shield film 9 without damaging it even in the case of the metallic light-shield film 9 being composed of not only the refractory silicide such as WSi but also metals including W and Mo.

[0042]

In the present embodiment, the gas introduced in the chamber 22 before forming the interlayer film 13 may be the oxygen gas 10 alone, the ozone gas 11 alone or the ozone gas 11 containing the oxygen gas 10. However, it is preferable to have more components of the ozone gas 11 since it results in faster oxidation of the surface of

the metallic light-shield film 9.

[0043]

Although the invention has been described in its preferred form with a certain degree of particularity, obviously many changes and variations are possible therein. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described herein without departing from the scope and the sprit thereof.